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ABSTRACT

The life work of both John Dewey and Lev Vygotsky and the implications for pedagogy that each of the theorist's work has generated is well known in the field of education. However, it is seldom that the theorists' works are juxtaposed for pedagogical considerations for specific subject matter. This is for at least three reasons: first, Dewey, of course, was primarily a philosopher of education, and Vygotsky, a psychologist. Second, there are major ideological differences between philosophers and psychologists. Another reason is that neither theorist's works specifically address a particular subject area. Nevertheless, such a juxtaposition is made here for the purpose of drawing crucial implications for the teaching and learning of tenth-grade geometric proofs. Additionally, this theoretical analysis demonstrates the posssibilities a multiple field analysis offers for innovative curricular practices. This paper provides an overview of the perceived role of proof in 10th grade geometry proof-oriented courses, and summarizes the pertinent works of John Dewey and Lev Vygotsky that offer pedagogical teaching implications in this area. (KHR)

Implications of John Dewey's and Lev Vygotsky's Theoretical Frameworks for the Teaching and Learning of 10th Grade Geometric Proofs

by

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Introduction

The life work of both John Dewey and Lev Vygotsky and the implications for pedagogy that each of the theorist's work has generated is well known in the field of education. However, it is seldom that the theorists' works are juxtaposed for pedagogical considerations for specific subject matter. This is for at least three reasons: first, Dewey, of course, was primarily a philosopher of education, and Vygotsky, a psychologist. Second, there are major ideological differences between philosophers and psychologists. Another reason is that neither theorist's works specifically addresses a particular subject area. Nevertheless, such a juxtaposition is made here for the purpose of drawing crucial implications for the teaching and learning of tenth-grade geometric proofs. Additionally, this theoretical analysis demonstrates the possibilities a multiple field analysis offers for innovative curricular practices. In what follows, I first provide an overview of the perceived role of proof in tenth-grade geometry proof oriented courses; next, I summarize the pertinent works of John Dewey and Lev Vygotsky that offer pedagogical teaching implications in this subject area.

The teaching and learning of proofs has long been considered a necessary component of mathematical learning. Harold Fawcett (1938) put it this way:

> The concept of proof is one concerning which the pupil should have a growing and increasing understanding. It is a concept which not only pervades his work in mathematics but is also involved in all situations where conclusions are to be reached and decisions to be made. Mathematics has a unique contribution to make in the development of this concept, and up to the present time teachers of mathematics have, in general, assumed this contribution can best be made in the tenth year through the study of demonstrative geometry.

The practice resulting from this assumption has tended to isolate the concept of proof, whereas this concept may well serve to unify the mathematical experiences of the pupil (p.12).

The teaching of tenth-grade geometry varies considerably in terms of the treatment of proofs. In many schools, geometry courses are "proof-centered." This means that the content of the course primarily involves using geometric statements (hypotheses) and definitions to prove other statements (conclusions) are true.

There has been considerable debate in the past two decades in regards to the role of rigorous proof in tenth-grade courses. Needless to say, there are extremist positions advocating that formal proof should not be a component of geometry courses; alternately, there are positions which argue the opposite. My interpretation of the NCTM standards (1989) is that proof is a valuable component of tenth-grade geometry, however, I do not believe it should be the sole focus of geometry courses. More specifically, I agree with the recommendations of mathematics educators who propose a shift from an over-reliance on rigorous proof toward a conception of proof as convincing argument (Shaughnessy & Burger, 1985; Hanna, 1990).

Shaughnessy and Burger (1985) modeling the van Hiele levels of geometric thinking concluded that "Students' introduction to geometry should be informal, without formal proofs or axiomatic treatment, for at least one-half year...Activities that encourage inference and deduction should also be included, but the writing of carefully structured formal proofs should be omitted" (p.426). [There is more discussion of the van Hieles' work later] In a similar position, Alibert (1988) recommended that teaching techniques should lay aside rigor and formality and focus instead on social aspects such as dialogue and argumentation (a type of informal proof). This view is also encapsulated by Knuth and Elliott (1998) who stated that

> An underlying emphasis of this literature is a call for teachers to give all students rich opportunities and experiences with mathematical proof. Further, these experiences also provide teachers with opportunities for examining the nature of their students' understandings of mathematical proof (p.4).

It suffices to say here that by encouraging students to dialogue, argumentize, and present their ideas in a non-threatening environment, valuable information can be gleaned regarding their experiences in a tenth-grade geometry course. This claim is rooted in philosophical and psychological literature.

The Work of John Dewey

Because human beings possess the capacity to think (as well as numerous other capacities), Dewey believed thinking is the instrument for change and survival in our social world. For Dewey, knowledge is not a vehicle for seeing some reality that exists. Instead, knowledge is an active relation which "makes" a reality. Knowledge therefore is an instrument for change (Dewey called this particular view of his, instrumentalism). What this means, is, that because human beings are capable of thinking, then thinking becomes an instrument for changing our environment (Dewey, 1910). In addition, human beings' capacity to think and then to further think about their thinking and its consequences, implies a crucial relationship between thinking and knowledge. That relationship is the potential for the generation of still more knowledge.

The foundation of his theory of education is his belief that education should reflect what people's situation actually is (we as organisms dealing with an environment). Education then should be experimental since our survival mirrors an experiment with our environment. To

describe Dewey's philosophy as experimental means that specific aims driving educational activities should be used as long as those aims succeed in guiding the learning activity. Dewey advised that students have aims for their learning (also called objectives). Hence teachers and students under Dewey's vision collaborate in an attempt to further the educational attainment of students. Such collaboration can result in learning for both parties. For teachers, learning in this context can occur in terms of pedagogy and content. That is, teachers can continue to learn how particular objectives impact students' learning; by reflecting on such an interaction, teachers can further reflect and attempt to make pedagogical adjustments in instruction.

To describe Dewey's philosophy as experimental also means that as human beings attempt numerous ways for solving problems that occur in their lives, they delve in various personal interests. In order to deal with these challenges, Dewey recommended the scientific method as the foundation for education. Dewey was born during the same year as Darwin's *The Origin of Species* was published. What may be of interest regarding this point is the influence that Darwin's ideas had on Dewey. It was Darwin who attempted to demonstrate using scientific methodologies of his time that human beings (mammals in his work) are biological organisms *actively* engaged in their environment. John Dewey adapted a lesson from Darwin concerning the goals of human beings, i.e., like all living creatures, humans are challenged to adapt to the environment which is in constant change (Cooney, Cross, & Trunk, 1993). "What survives is successful; truth= what works" (Cooney, Cross, & Trunk, 1993, p.134).

Dewey believed that the purpose of education is to foster further educational growth in an individual. When pressed to elaborate on what he meant by growth, Dewey told his critics that growth is its own end. "To ask 'growth toward what?' is inconsistent with the concept of

growth" (Noddings, 1995, p.26). Growth results in further growth, argued Dewey, and the concept would become rigid if direction of growth was specified. More specifically, Dewey believed that experience is educative only if growth results. This can be interpreted to mean that students grow if they leave a particular experience either more capable then they were before, or, interested in engaging in new and possibly related experiences. In light of this, Noddings (1995) asked:

> Should we not, then, elaborate on the normative meaning of growth? Should we not describe in detail episodes that clearly deserve the label *growth*? I am not sure Dewey would object to such attempts. They could be part of a conversation he intended to initiate. But he would surely object strongly if our efforts culminated in a singular ideal toward which all growth must move (p.27).

For Dewey, the central purpose of education is more education. Included in this, is education which has particular aims. However, Dewey cautioned that while educative activities must by their very nature have aims, those aims should not be fixed. In fact, the greatest aim for Dewey is continued education.

Let us now consider the premise that the aims of educational activities should not be fixed. This at least then implies that the role of the teacher should include a continual assessment of her/his classroom or students, in order to determine students' needs and concerns (in the discipline of sociology this type of idea is referred to as "the definition of the situation"). In Dewey's schema then, the teacher's role includes a process of continuous assessment of the classroom situation. This helps the teacher define the situation, which in turn helps the teacher and

students identify educational aims. Those aims should be used as long as the teacher and students believe that they are guiding the learning activity. In fact, "Dewey preferred to see the relationship between the teacher and student as one of 'learners together'" (Cooney, Cross, & Trunk, 1993).

> The cornerstone of Dewey's theory of education is his belief that education should begin by mirroring what our situation actually is, i.e., we are organisms dealing with an environment. So then, education should be *experimental*, since our survival reflects an experiment with the environment--we do try many alternative ways for solving problems that we come up against in our world. And Dewey offers the scientific method as a model for the proper way to deal with these challenges and the best foundation for education in general. The experimental nature of education, indeed, is consistent with the spirit of democracy too, which is necessarily open to workable alternatives (Cooney, Cross, & Trunk, 1993, pp.135-136).

If, indeed, education should be experimental (my position is that it should be), then educators should hesitate in bringing preconceived absolutes into instruction. By absolute, I am referring to instructional techniques or strategies used by teachers and other educators for all students. In the extreme case, deviation from such techniques does not occur. Thus the act of teaching can become overly prescriptive. An extreme prescriptive teaching approach presumingly utilizes a set of teaching acts or instructional strategies that are rarely modified. [An extreme example is a teacher who uses lecture as the only pedagogical technique. In such a class, students may be expected to listen, copy examples in written form, and then practice what was

demonstrated by performing a set of textbook exercises] The underlying assumption in extremist prescriptive pedagogies is that specific techniques work best for all students. For example, in mathematics, students may be taught specific sets of isolated facts, skills, and procedures, for example. However, if learning does not encompass social experiences, Dewey believed students would withdraw from the educational process or become passive recipients of knowledge. Consequently, he rejected the style of education which overly focuses on subject-matter knowledge. This type of knowledge sees or assumes the child is a passive receiver of specific content which has been determined by others to be essential to acquire. My interpretation of Dewey's rejection of subject-matter as a central focus of education is that subject-matter should not be taught in isolation. Today, many call for integrated curricula in our schools. For example, how can specific content in mathematics be juxtaposed with content in science? I think the teaching of content without reference to other fields of study is, in part, what Dewey rejected.

First, Dewey believed that learning which concentrates on the collection of isolated facts, skills, and processes, ignores the crucial impact of each individual's social experiences.

> The nature of experience can be understood only by noting that it *includes an active and passive element particularly combined* [italics are mine]. On the active hand experience is trying...On the passive, it is undergoing. When we experience something we act upon it, we do something with it; then we suffer or undergo the consequences...Mere activity does not constitute experience. It is dispersive, centrifugal, dissipating. Experience as trying involves change, but change is meaningless transition unless it is consciously connected with the return wave of the consequences that which

> flow from it...*doing becomes a trying; an experiment with the world to find out what it is like*; [italics are mine] the undergoing becomes instruction--discovery of the connection of things (Dewey, 1916, pp. 163-164).

Thus for Dewey, "education must be conceived as a continual reconstruction of experience; that the process and the goal of education are one and the same thing..." (Dewey, 1897, p.15).

The second contribution of Dewey is his belief that the child should be the starting point of education (thus the term "child-centered" education). The point of educational departure is the child's own initiatives and interests (Dewey, 1902). These psychological experiences must be interconnected with children's logical experiences; the source of children's logical experiences is school subject matter. Put differently, the institution of schooling should be an outgrowth of the child's home life. In Dewey's (1897) words, "it should take up and continue the activities with which the child is already familiar at home (p.20).

The importance of the interconnection of children's psychological and logical experiences is emphasized in Dewey's (1902/1956) work:

> The logically formulated material of a science or branch of learning, of a study, is no substitute for the having of individual experiences...But, the map, a summary, an arranged and orderly view of previous experiences, serves as a guide to future experience; it gives direction; it facilitates control; it economizes effort, preventing useless wandering, and pointing out the paths which lead most quickly and most certainly to a desired result...That which we call a science or study puts the net product of past experience in the form which makes it most available for the future. It represents a capitalization

> which may at once be turned to interest. It economizes the workings of the mind in every way...Observation is assisted; we know what to look for and where to look. It is the difference between looking for a needle in a haystack, and searching for a given paper in a well-organized cabinet. Reasoning is directed, because there is a certain general path or line laid out along which ideas naturally march, instead of moving from one chance association to another...The logical is not set over against the psychological; The surveyed and the arranged result occupies a critical position in the process of growth. It marks a turning-point. It shows how we may get the benefit of past effort in controlling future endeavor. In the largest sense the logical standpoint is itself psychological; it has its meaning as a point in the development of experience, and its justification is in its functioning in the future growth which it insures (pp.20-22).

Dewey's third major contribution is the acknowledgment of the crucial role that the teacher plays in the process of education. That role was described earlier in this chapter. However, I will now close the discussion on Dewey's philosophy of education here by discussing teaching implications of his work. These implications also provide the basis for the approach taken in this study.

Since Dewey believed an experience is educative only if it is connected to other prior experiences, teachers need to consider where students are in their learning. This can mean that they create conversations in the classroom which allow students to relate to or at least become aware of their own and their peers' thinking. This also gives the teacher a sense of the experiences students have had outside of school as well as inside of school. Next, teachers and students can

consider where their prior experiences can now lead them to. In doing this, teachers can then prepare subject matter in light of students' preparation and future needs. Doing this results in at least two implications. The first, is that the logical structure of subject matter as described by textbook authors or other specialists may not be pedagogically adequate at a given time. Second, in order to foster a continuity of experience, students must be engaged; that is, they must be involved in an interaction between themselves and the subject matter they are studying. If students are learning subject matter for the sake of learning it, that is, without any attempts to connect knowledge to experiences, then the result can be boredom with schooling and/or particular subject matter.

In sum, Dewey's work emphasized the importance of both the psychological and social aspects of education. Dewey considered these aspects reciprocally: that is, each is dependent on the other. The teacher/child relationship is one in which both are involved in a "process of living." Or, they are both in the "real world" now. [One cannot help but think that Dewey would reject the familiar cliche that school prepares individuals for the "real world." This cliche implies that when students are in school, they are in some artificial setting.]

Since the school is a social institution for Dewey, it is a primary source for "social consciousness, progress and reform" (Cooney, Cross, & Trunk, 1993, p.147). Thus when we spend resources on the institution of education, we are *investing* on the improvement of our society.

Because for Dewey, the child is active and not a passive recipient of knowledge, teachers should not "impose" ideas and knowledge on children (quotations are mine). Instead, their role should be to direct and guide students' needs and desire to learn. As Varelas (1992) put it: "For

Dewey, teaching is directing the students' experiences towards the adult's/expert's view of a subject matter and the teacher plays a crucial role in guiding the students' experiences, especially helping them develop meaning out of them" (p.8).

The Work of Lev Vygotsky

Vygotsky placed a great emphasis on the nature of social interaction--particularly between adults and children. He believed that by manipulating language (especially in formal learning environments such as schools) and the development of scientific concepts, a conscious awareness of important aspects of both everyday and formal concepts occurs. Let us now explore this as well as other premises that Vygotsky's psychology offers the field of education.

Vygotsky's work is usually categorized into four components: (1) Language plays a central role in mental development, (2) learning can lead development, (3) children co-construct knowledge, and (4) development cannot be separated from its social context. In the first component, Vygotsky believed that language is a mechanism for thinking. It is the means by which information is passed from one generation to another. Sociologists tell us that language is the most crucial component of culture (aside from beliefs, values, mores, folkways, and so forth).

Language allows us to think about and discuss things. By using language, all world cultures have passed on higher mental functions helping succeeding generations make sense of their world. Vygotsky specifically discussed this position in *Thought and Language* (1986). In that work he elaborated on how learning involves our external experience to be transformed into internal processes through the mediation of language. Thus language is the medium which carries experiences into the mind. When we are teaching a child a new skill, we instruct the child as to what we want done. The child then appropriates the instructions and uses them independently as a

regulator of personal behavior. Consequently, learning moves through a cycle of exterior and interior prompts eventually adapted by the child in his/her personal repertoires. Again, language is the medium used by us and the child to evaluate experiences in order for us to become independent learners.

Vygotsky recommended we encourage children to talk about their learning experiences (to us and their peers), and write about them. His aim was to foster development of independent, self-regulating individuals who could function with others in using past lessons to master present tasks or concepts (Moll,1990). Vygotsky elaborated further on this through his discussion of the zone of proximal development (ZOPD) as a way for teachers to influence and guide students' active learning processes (more on the ZOPD shortly).

In the second component of Vygotsky's work, he stressed that learning impacts our development. This means that some of our learning is a function of maturation. Take early mathematics for instance. Learning skills can hasten a child's development. Instead, for instance, of viewing early counting as simple recitation, Vygotsky argued that counting helps adjust the child towards the concept of the symbolic nature of number. Thus Vygotsky assigned great value to assisting children in using strategies to further intellectual capacities (ZOPD). Let us consider a simple example. Suppose a four-year old is asked to count a specific set of toy cars. Suppose the child counts to 14. This is considered his/her independent task. However, if the teacher can structure the activity in an alternative manner and can lead the child to count to 18 meaningfully, without missing any cars, then the child has counted to a higher level with assistance. This higher level which the child can achieve only with assistance is called the level of assisted performance. It is the area between the level of independent performance and the level of assisted performance

which Vygotsky called ZOPD. Vygotsky recommended that teachers need to focus attention for children's further development at the ZOPD. However, he never "specified the forms of social assistance to learners that constitute a zone of proximal development" (Moll, 1990, p.11). He did however, highlight the "importance of everyday activities and content in providing meaning, the 'conceptual fabric' for the development of schooled concepts" (Moll, 1990, p.10). For schooling to be significant or meaningful for the student "everyday" (or informal) knowledge must be juxtaposed with scientific concepts. "It is through the use of everyday concepts that children make sense of the definitions and explanations of scientific concepts; everyday concepts provide the 'living knowledge' for the development of scientific concepts" (Moll, 1990, p.10). Put differently, everyday concepts mediate how we acquire scientific concepts. It should not be assumed that this is an ordered process. By this, I mean that Vygotsky (1987) also stated that everyday concepts are mediated and may be transformed by scientific concepts.

The third component of Vygotsky's work stressed that children co-construct knowledge. For Vygotsky, children do not simply passively reproduce knowledge that is presented to them. Because learning is much more complex than the mirroring of what one encounters, learning always involves learners creating personal representations of new knowledge (there is a link here to the work of Piaget, however, Piaget believed the child constructs knowledge primarily in his/her interaction with physical objects). For Vygotsky, learning always involves more than one human; it is co-constructed as students interact with each other, their teachers, and their environment. The process of constructing knowledge is reflective as well as social.

In the fourth component of Vygotsky's work, social contexts influence children's attitudes, beliefs, and thinking processes (Moll, 1990). Although he believed that the content and

processes we use in thinking are determined by the norms of our culture, he thought that there exists a similar structure of mind in all humans. By this, he meant that there are two levels of mental functioning--lower and higher. The former can be described as innate, such as reacting to loud sudden noises. The latter, Vygotsky considered unique, passed on from prior generations. Examples include the ability to use symbolic thought.

Implications for Teaching Tenth-Grade Geometric Proofs

How might we apply Dewey's work to geometric proofs? Recall that Dewey's philosophy can be described as experimental. A crucial implication for the teaching and learning of geometric proofs is that what is presented in students' textbooks should not be considered as absolute. By absolute in this case, I am suggesting that textbook authors and teachers of geometry remind students that there can be various solution strategies to specific problems. This may seem a very obvious point, however, in many mathematics classes it may still be easily forgotten. In non-inquiry classrooms the text is often considered as the authoritative source on mathematics problem solving in terms of problem presentation and structure. This perception is often held by students, but it is often held by teachers as well. Dewey reminds us that students and teachers must reflect on the educational process. They should continue to reflect on educational aims and pedagogical strategies enacted to reach those aims. By such reflection, students and teachers can negotiate changes in pedagogy to reach particular aims. However, it up to the teacher to encourage and model such a philosophy in the classroom by inviting student interpretations of mathematical solution strategies and help them offer alternative ones. When a learning environment is characterized with a high level of meaningful social interaction and collaboration between students, and between students and teachers, possibilities for generating new knowledge

and understanding can further be realized. This further implies that it is extremely valuable (particularly when students struggle with difficult subject matter) that they be prompted and encouraged to generate alternative strategies that can be used in comparison to what is presented in their textbook. Such comparisons can result in meaningful dialogue and argumentation that can result in further learning and understanding.

Vygotsky's work has tremendous implications for teaching and learning mathematics. From his perspective, a major role of schooling is to create social contexts or zones of proximal development for students to master. Moll (1990) put it this way:

> It is by mastering these technologies [cultural tools] of representation and communication (Olson, 1986) that individuals acquire the capacity, the means, for 'higher-order' intellectual activity. Thus Vygotskian theory posits a strong dialectical connection between external (i.e., social and, as we noted above, extracurricular) practical activity mediated by cultural tools, such as speech and writing, and individuals' intellectual activity (p.12).

In the Vygotskian schema then, the role of the adult is not only to provide structurally characterized prompts or cues for students, but also discussion which values critical inquiry and other social mediations. Those can include, for example, students' personal everyday activities which can be used by students to take control of their learning. When students take control, they create meaning for themselves and others. When meaning results for students there is movement within the ZOPD. This means that a change in the individual occurs. The student can then do something new independently that he/she could only do with assistance prior to the creating of

meaning.

Although the psychological work of Vygotsky differs in terms of its epistemological nature as well as its heuristic educational application to the philosophical work of Dewey, there are useful connections that can be made of their work particularly for the approach taken in thispaper. A personal interpretation is that Dewey's notion of education as experimental and social complements Vygotsky's perspective as discussed above. Although, I acknowledge that there are numerous differences between philosophers and psychologists, both Dewey's and Vygotsky's emphases on the impact of experiential processes, is a crucial component that all teachers must attempt to include in their pedagogy.

John Dewey's and Lev Vygotsky's works provide educators with a general approach that emphasizes human activity into a form of meaning and psychological development. Using the work of these theorists, educators need to examine current educational practices in order to determine if modification in specific school practices are necessary. For the scope of this paper, current educational practices regarding the teaching of tenth-grade geometry can be analyzed and perhaps modified if necessary, after an approach to teaching is undertaken as suggested by the aforementioned theorists. A further implication of the works of Dewey and Vygotsky is that social settings or circumstances in the educational milieu can and should be altered when deemed reasonable and possible by students, teachers, and other educators. In terms of instruction, when the focus is strictly on isolated skills and subskills without reference to social contexts, then the "social" is removed from the process of learning. In my view, this recitative-type of teaching is what Dewey and Vygotsky considered to be anathema to the process of learning if it became the only pedagogical technique in the classroom.

This review of literature suggests secondary school mathematics teachers seriously consider the adoption of an "inquiry classroom" for their students. Educational administrators should further allow teachers to experiment with different classroom teaching approaches that include a collaborative component between students, and students and their teachers.

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